Extrusion Modules (WBS 1.5/2.5)

Ken Heller
University of Minnesota

NOνA Review
August 16, 2006

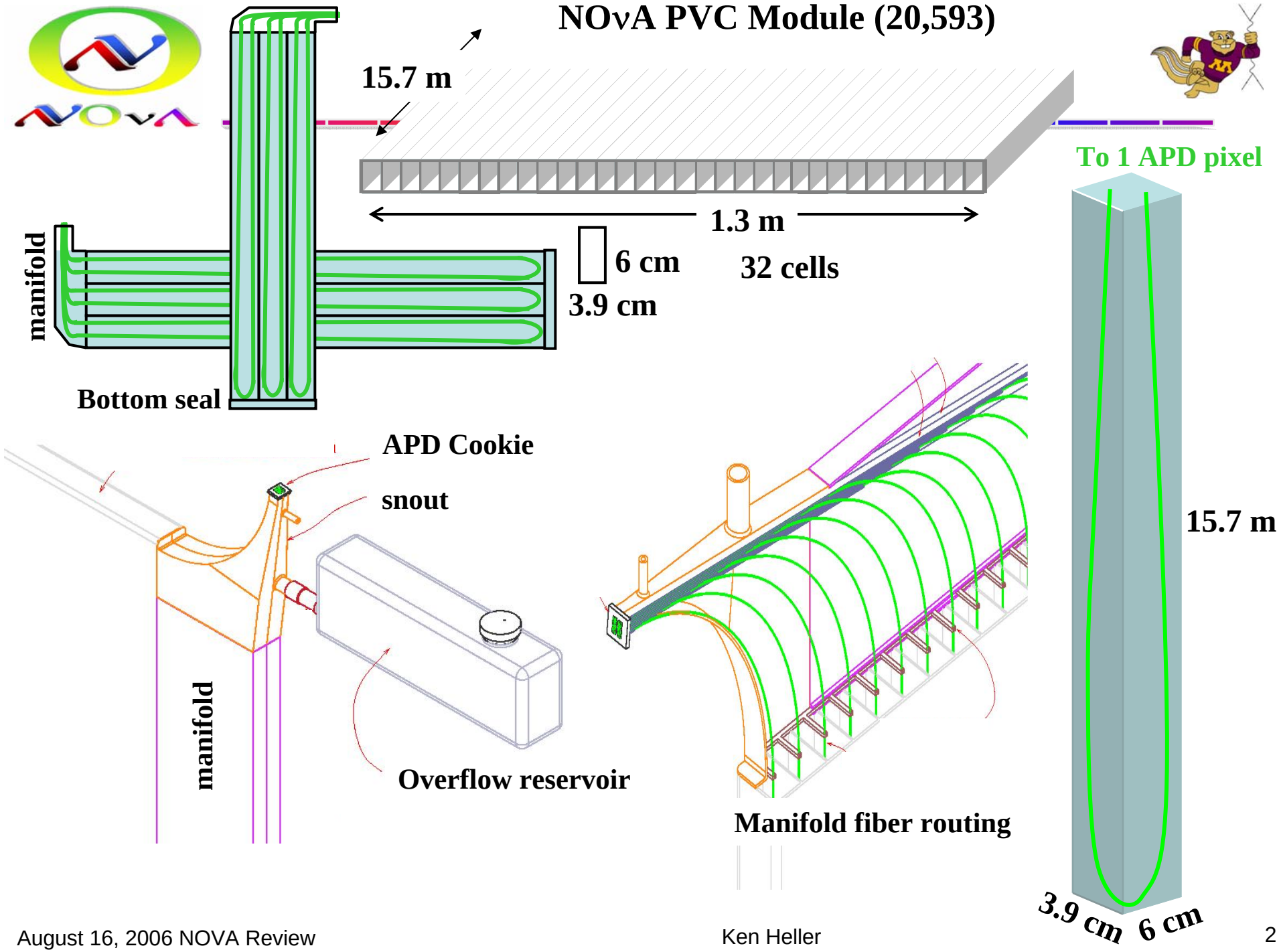
Level 3 Managers

Tom Chase
Dan Cronin-Hennessy
Jim Grudzinski
Ron Poling
Jon Urheim

Other Contributers

Dan Ambrose
Jen Dockter
Vic Guarino
Sara Horn
Hans Jostlein
Karen Kephart
Bill Miller
Leon Mualem
Stewart Mufson
Jim Musser
Ben Nitti
Keith Ruddick
Rodger Rusack
Alex Smith
Matt Strait
Dan Sword
Rich Talaga
Alex Tannenbaum

NOνA PVC Module (20,593)



Results of Lehman Review

PVC Modules

Recommendations:

- Ready for CD-1 approval.
- Revisit the time and motion studies for module assembly using experience gained with 16 cell extrusions. **16 cell extrusions not yet delivered**
- Perform an ergonomic assessment for module assembly, in particular the manual trolley crane movement. **Need 16 cell extrusions and crane**
- Design the fiber retainer to maintain fiber bend radius for filling and during transportation. **Prototype designed**
- Develop a plan for use and maintenance of the vacuum lifters. **Not yet**

Lehman Comments

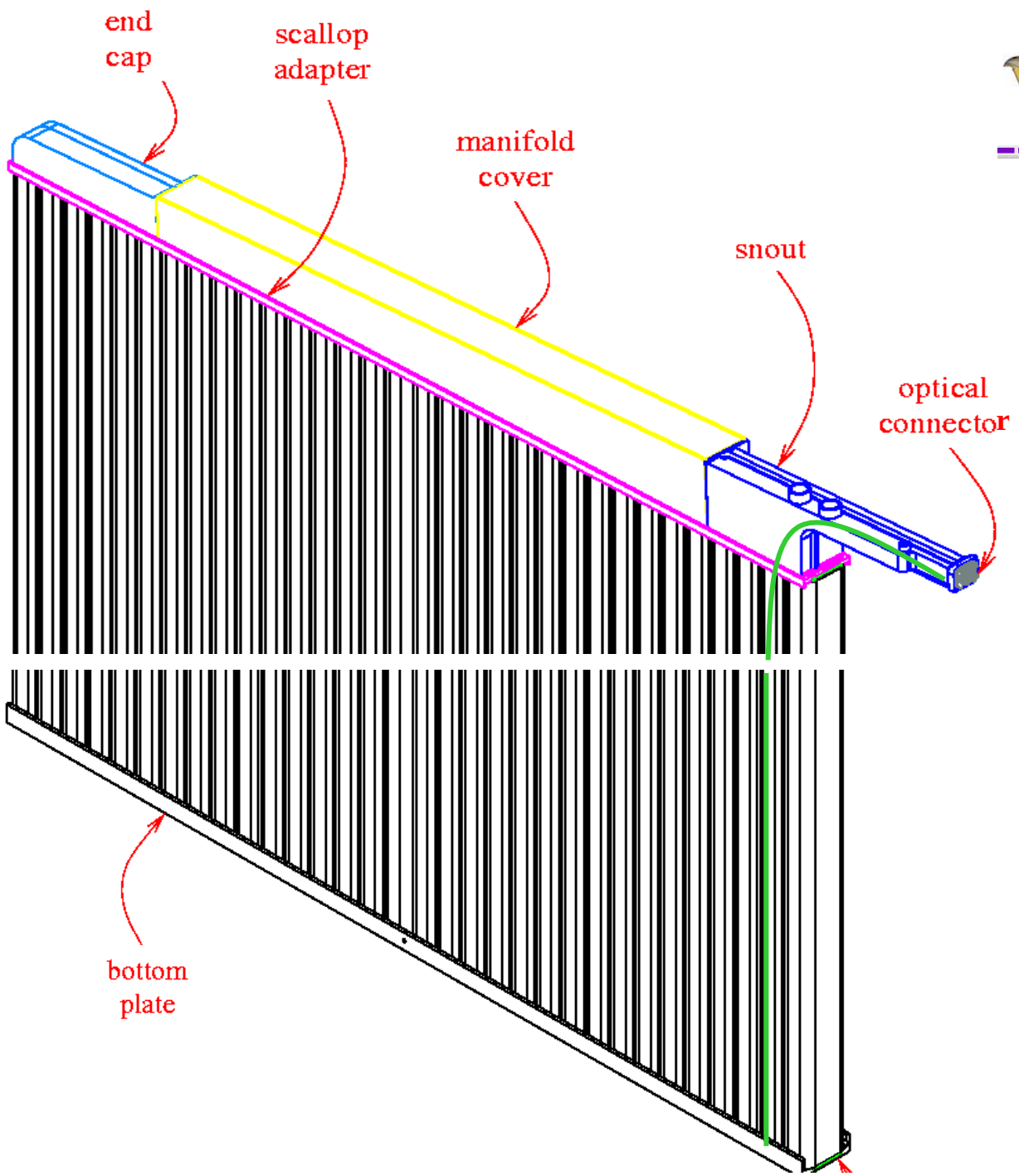
The committee commends the team for their effort and progress so far, and comments that:

- labor estimates for module assembly appear lean. **Will revise with 16 cell extrusions**
- although 100% contingency on labor for assembly seem high, the time allotted for the tasks appear tight, so the high contingency is justified.
- more engineering effort needs to be focused on module assembly time and motion studies. **Design of modules and elements progressing**
- consider increasing the number of bridge cranes to one per assembly cell; include stops to limit trolley travel in each cell. **Yes**
- consider scissor tables, etc., for module movement and assembly. **Yes**
- design tooling to clamp the end plug manifold and bottom plate to the extrusion during gluing. **Assembly method changes**
- evaluate and define the epoxy for vertical curing. **In progress**
- methodology for the cost estimate appears adequate.
- the task manager shows surprisingly good connection to the schedules.
- manpower appears to be adequate to get to CD-2. The team realizes the need to hire the first factory manager soon. **Begins September 15**
- structural analysis support appears somewhat thin.
- the team should evaluate the engineering manpower profile between the R&D and production phases for continuity. **Yes**

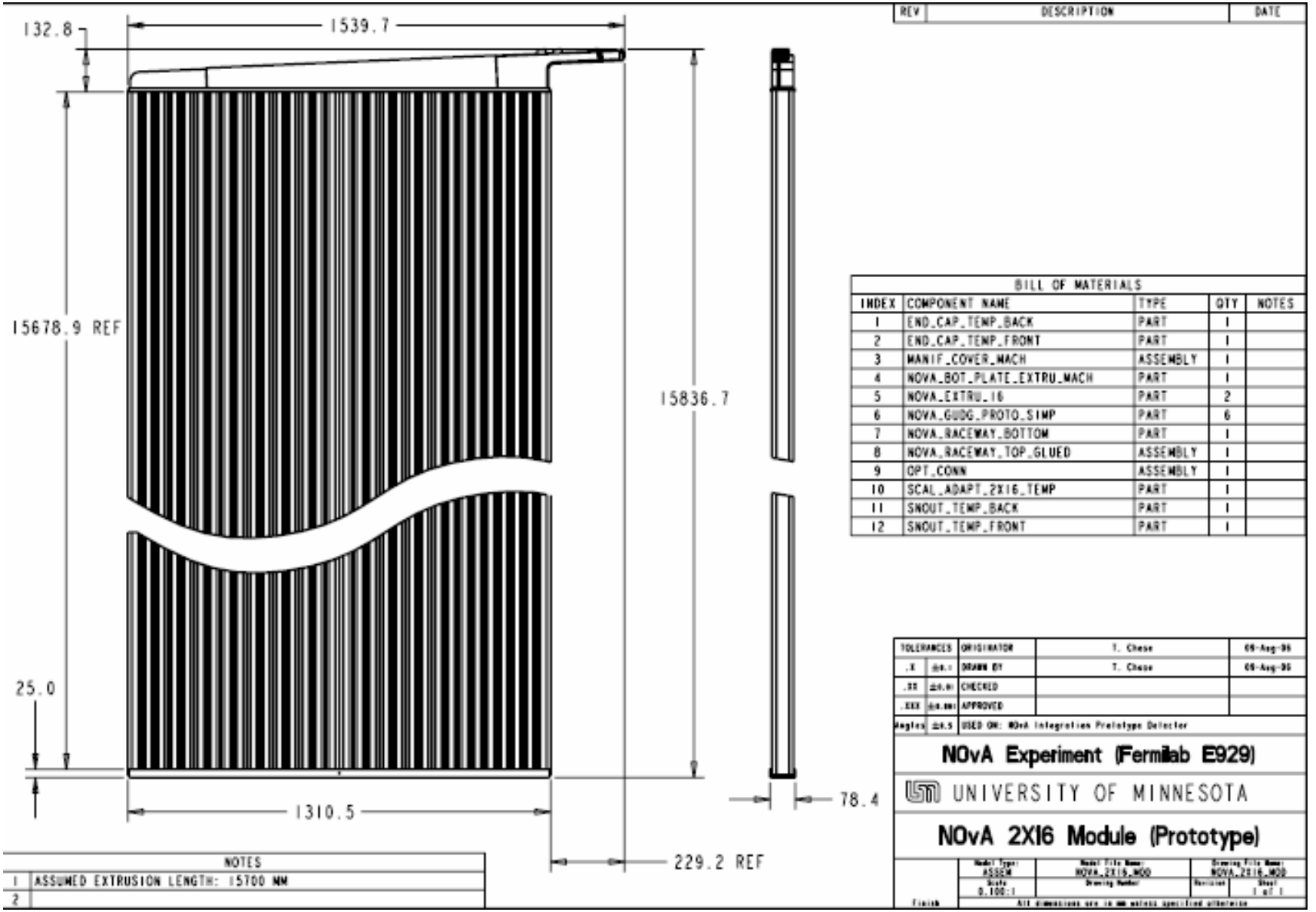
Major Progress

- **Manifold Design**
- **End Seal Design**
- **Sealing and leak detection**
- **Assembly procedure**
- **Machines**
- **Quality Control**

Module Design



Module Dimensions



REV	DESCRIPTION	DATE

BILL OF MATERIALS

INDEX	COMPONENT NAME	TYPE	QTY	NOTES
1	END_CAP_TEMP_BACK	PART	1	
2	END_CAP_TEMP_FRONT	PART	1	
3	MANIF_COVER_MACH	ASSEMBLY	1	
4	NOVA_BOT_PLATE_EXTRU_MACH	PART	1	
5	NOVA_EXTRU_16	PART	2	
6	NOVA_GUDG_PROTO_SIMP	PART	6	
7	NOVA_RACEWAY_BOTTOM	PART	1	
8	NOVA_RACEWAY_TOP_GLUED	ASSEMBLY	1	
9	OPT_CONN	ASSEMBLY	1	
10	SCAL_ADAPT_2X16_TEMP	PART	1	
11	SNOUT_TEMP_BACK	PART	1	
12	SNOUT_TEMP_FRONT	PART	1	

NOTES	
1	ASSUMED EXTRUSION LENGTH: 15700 MM
2	

TOLERANCES		ORIGINATOR	T. Chase	09-Aug-06
.X	±0.1	DRAWN BY	T. Chase	09-Aug-06
.XX	±0.01	CHECKED		
.XXX	±0.001	APPROVED		
Angles	±0.5	USED ON: NOvA Integration Prototype Detector		

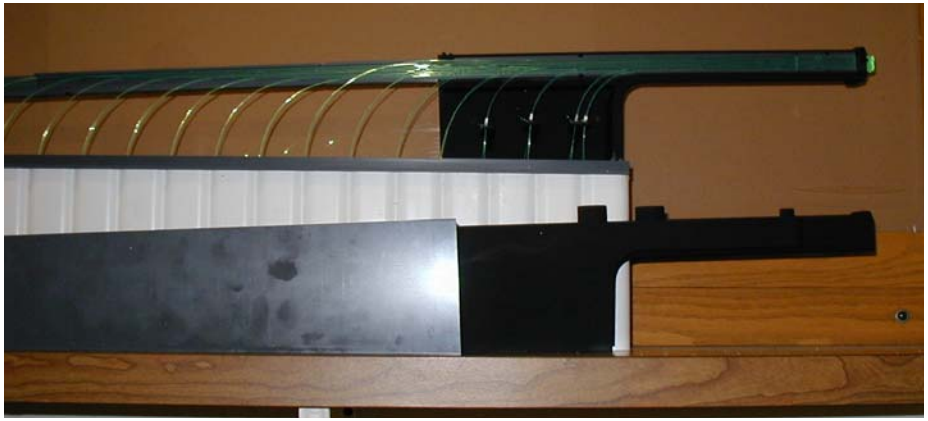
NOvA Experiment (Fermilab E929)

UNIVERSITY OF MINNESOTA

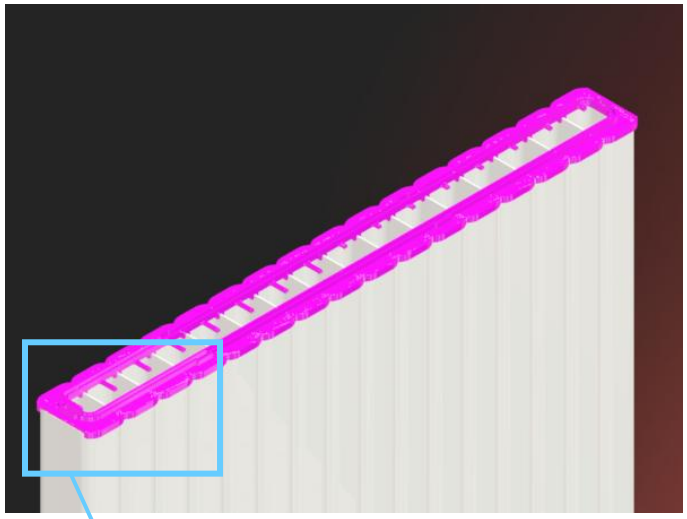
NOvA 2X16 Module (Prototype)

Finish	Model Type: ASSEM	Model File Name: NOVA_2X16_MOD	Drawing File Name: NOVA_2X16_MOD
	Scale: 0.100:1	Drawing Number	Revision / Sheet: 1 of 1
	All dimensions are in MM unless specified otherwise		

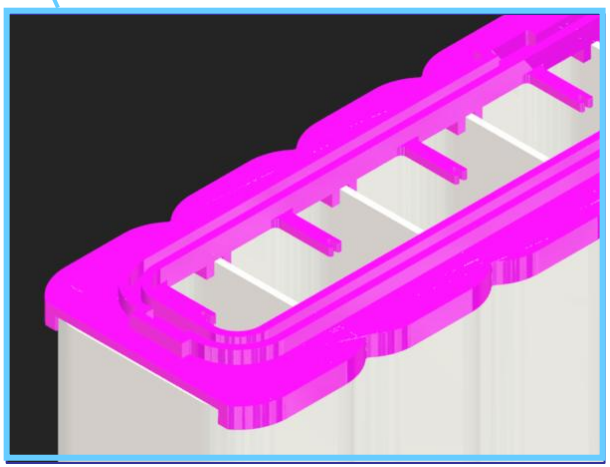
Manifold

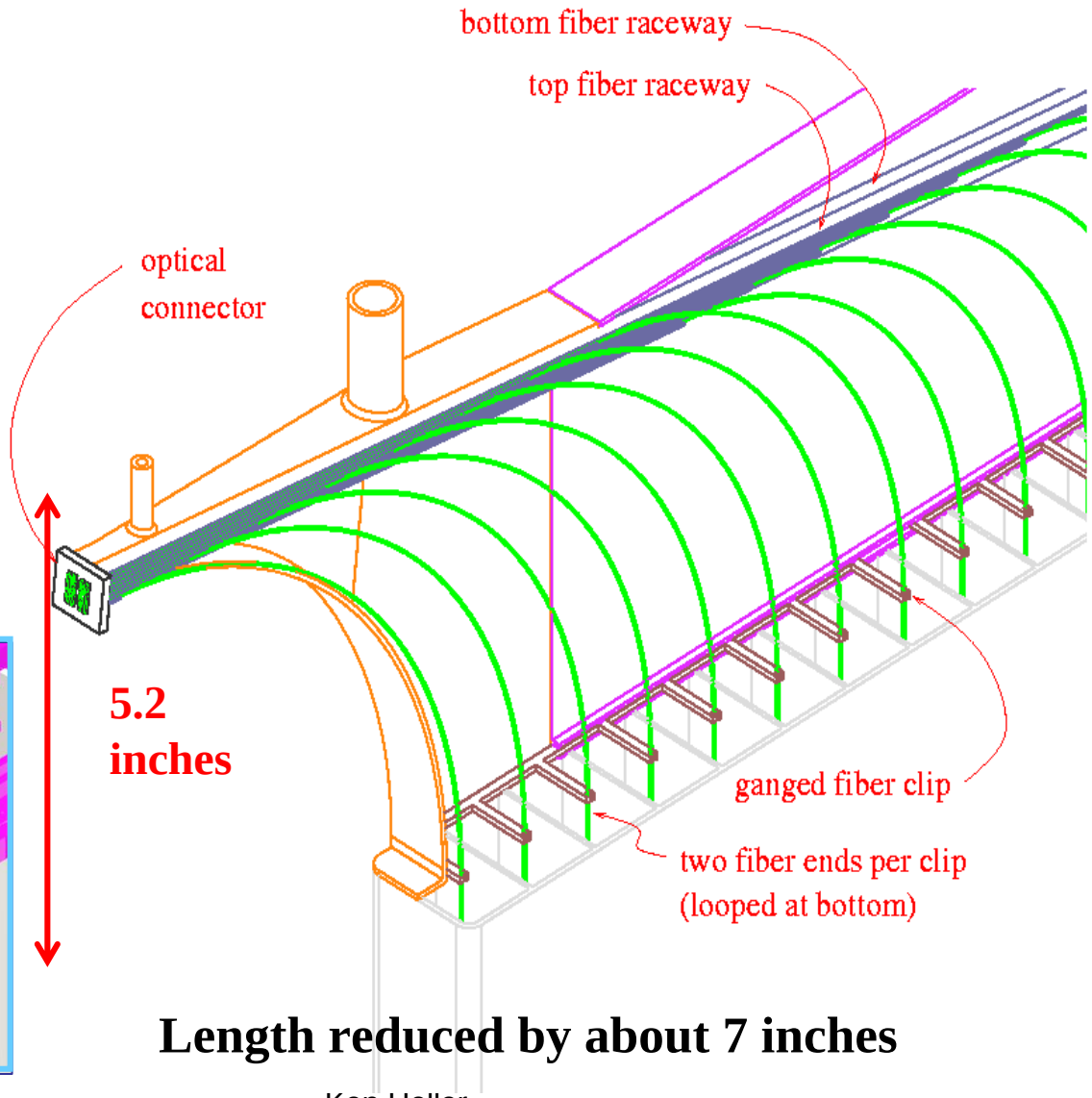


Manifold Details



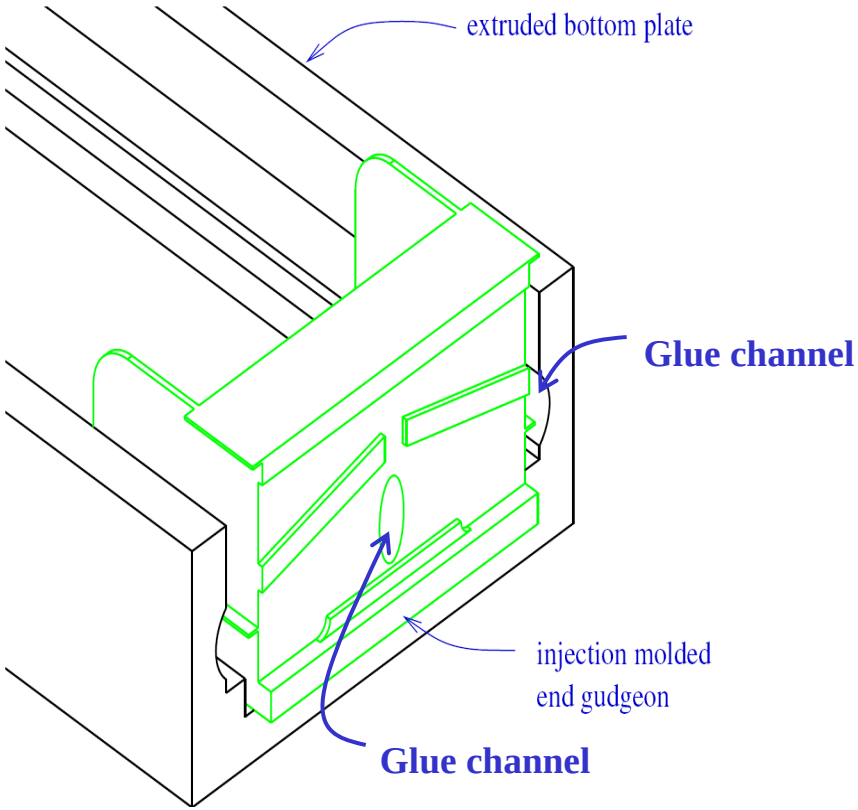
Manifold scallop adaptor

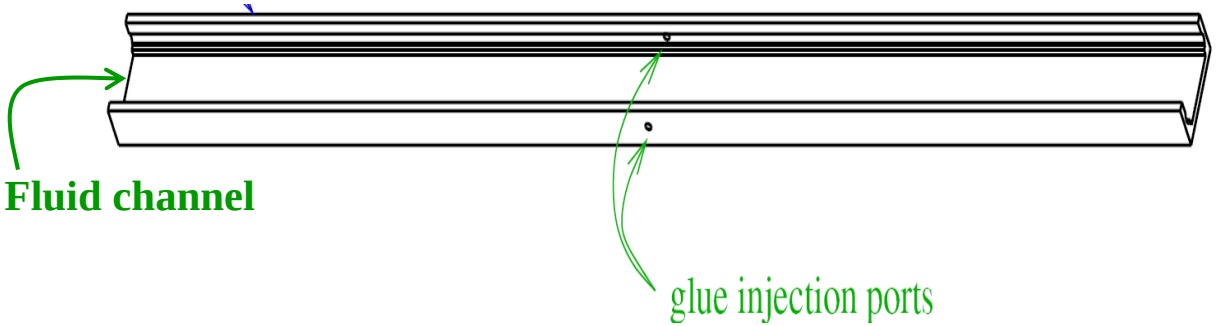




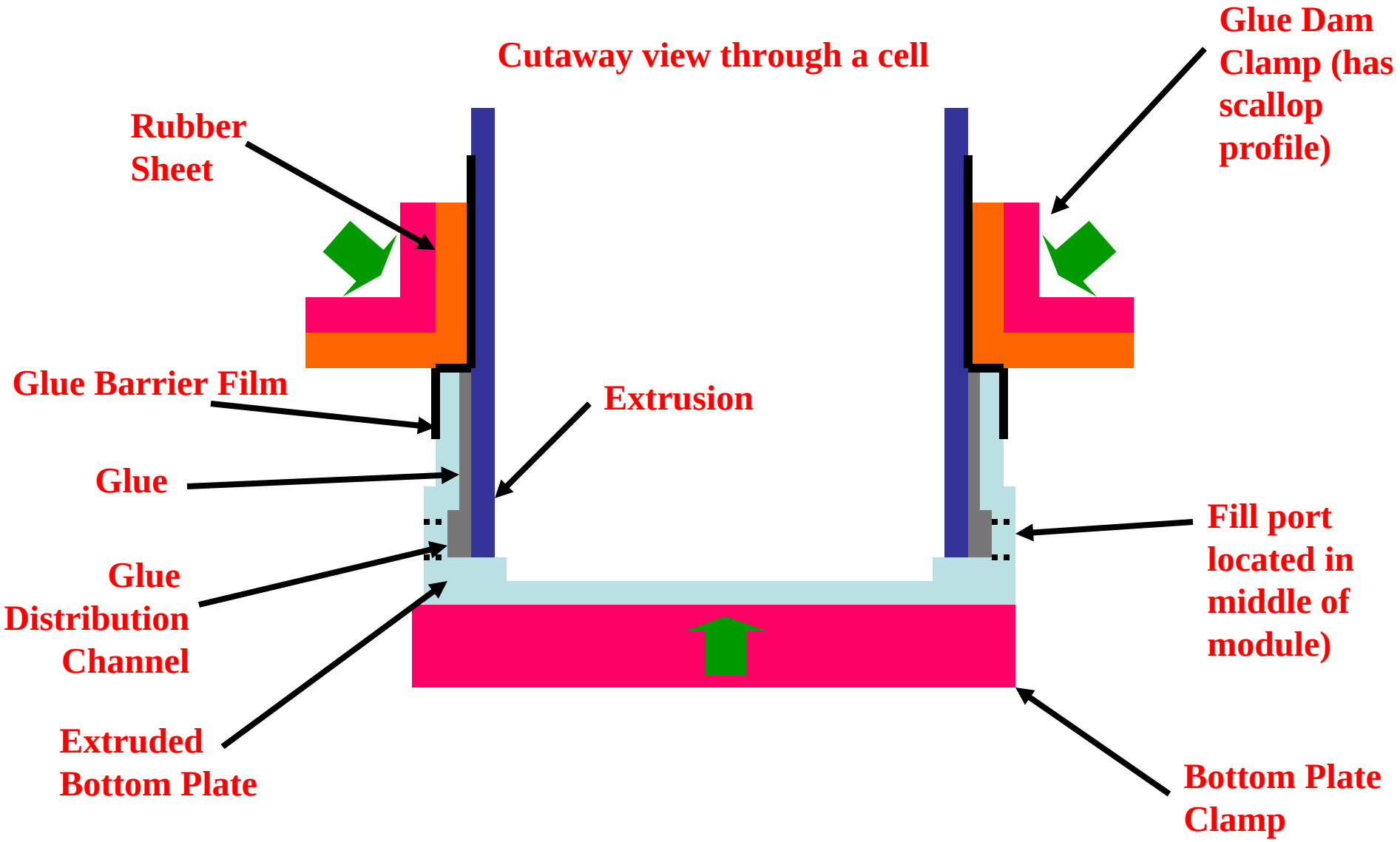
Length reduced by about 7 inches

Bottom Seal

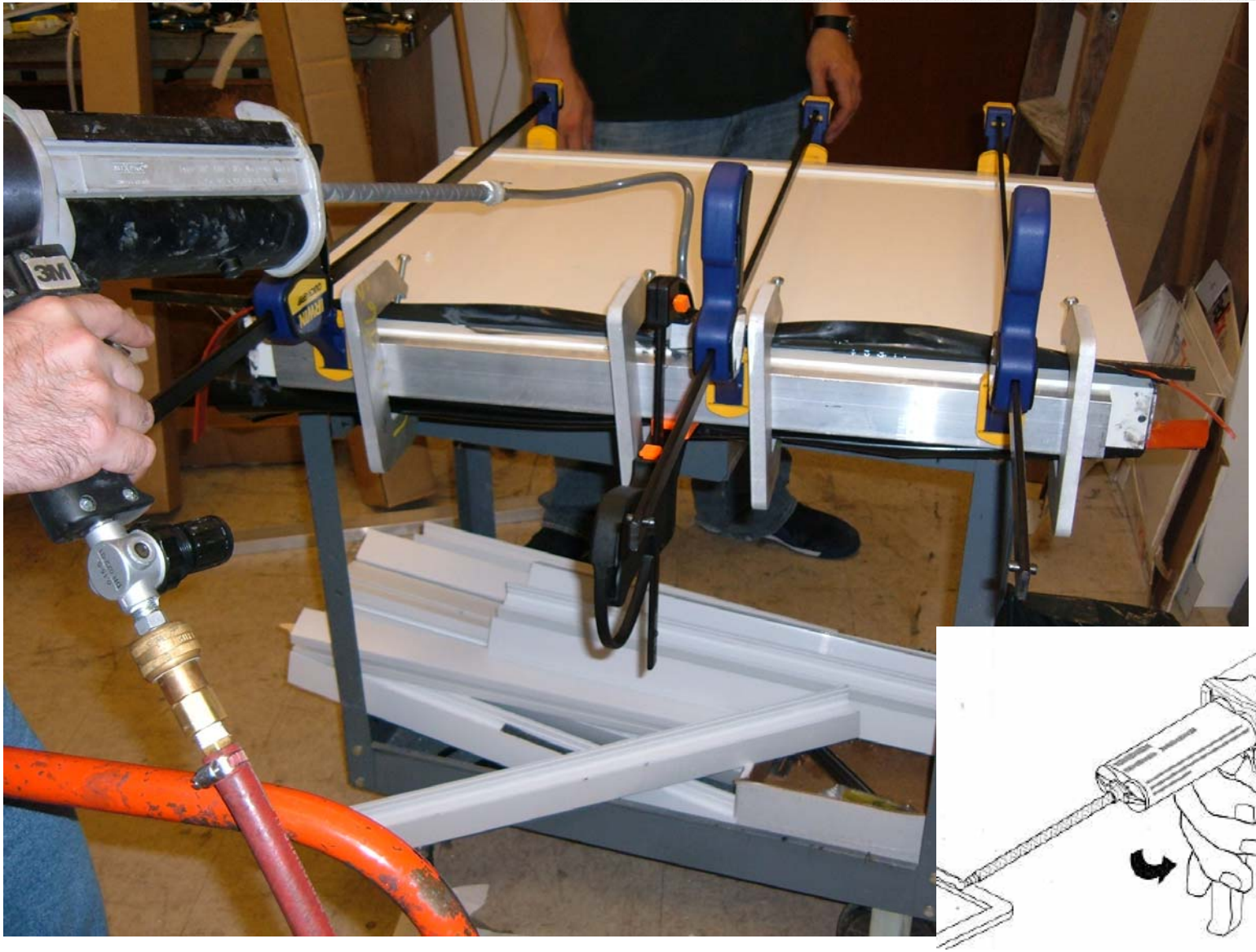

extruded bottom plate
Glue channel
injection molded
end gudgeon
Glue channel


Fluid channel
glue injection ports

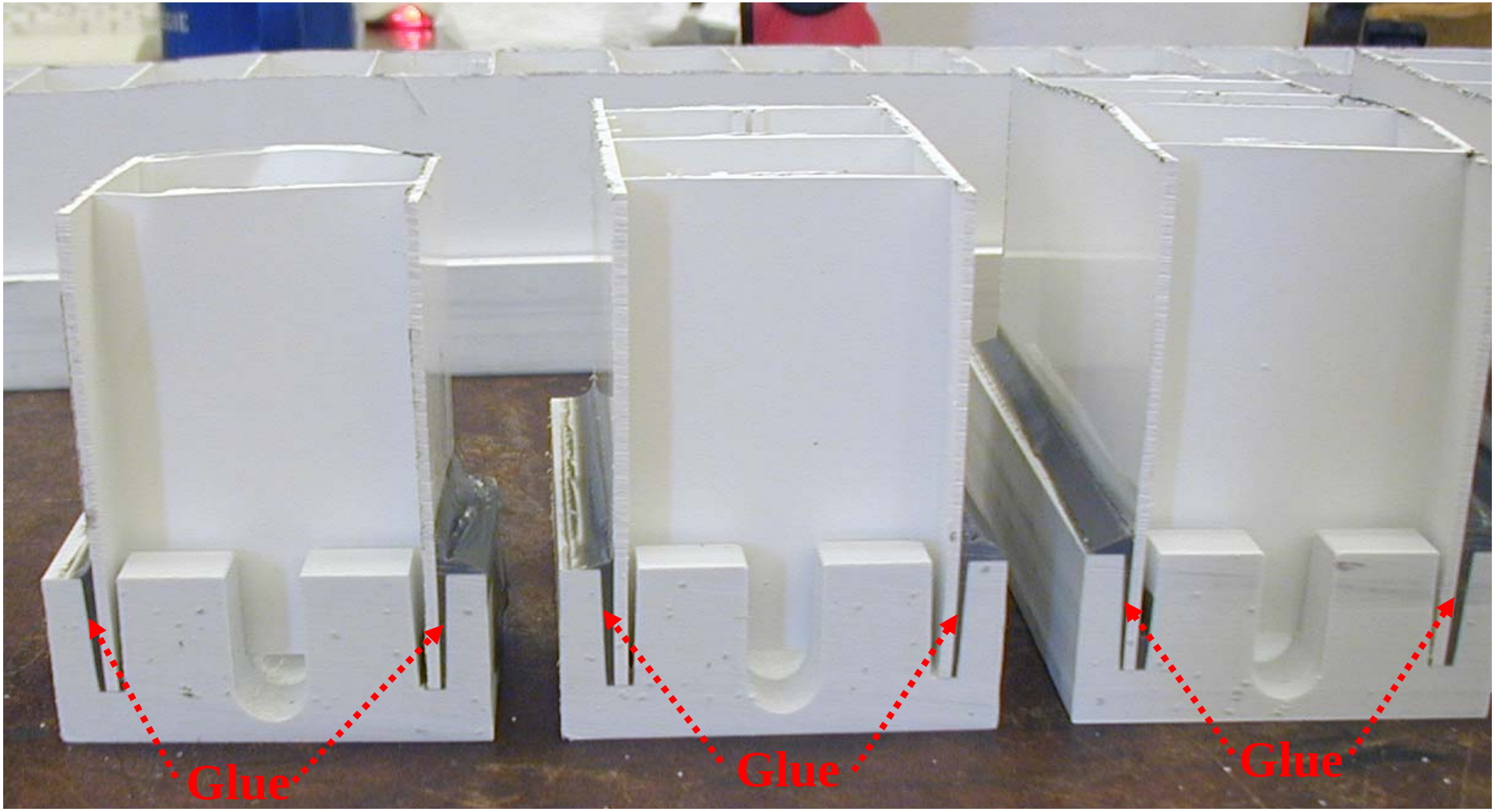
Glue Seal of Bottom Plate



Pumping Glue

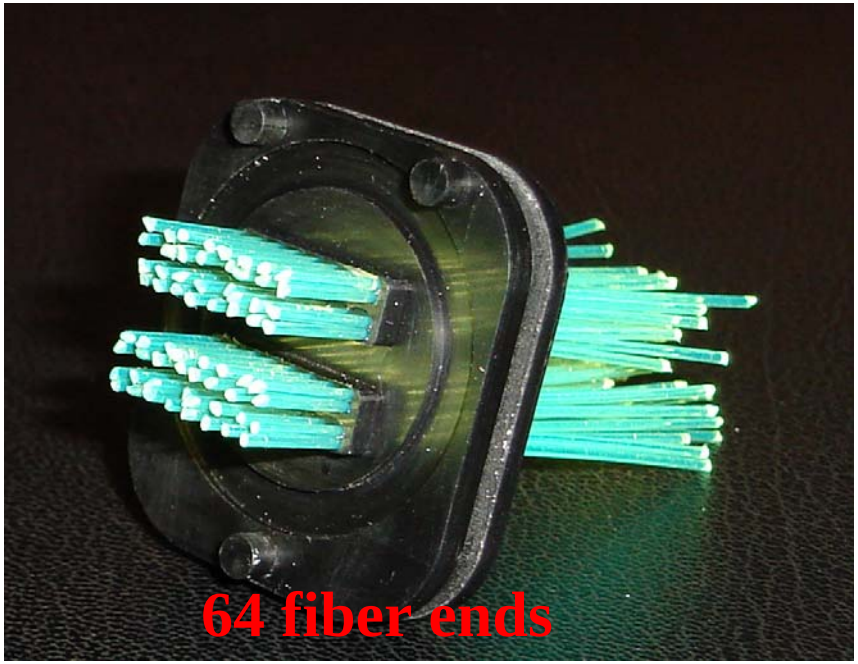


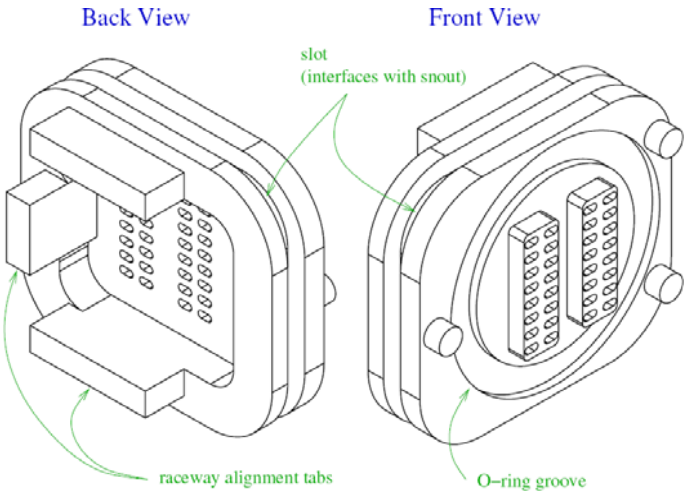
Bottom Seal Tests



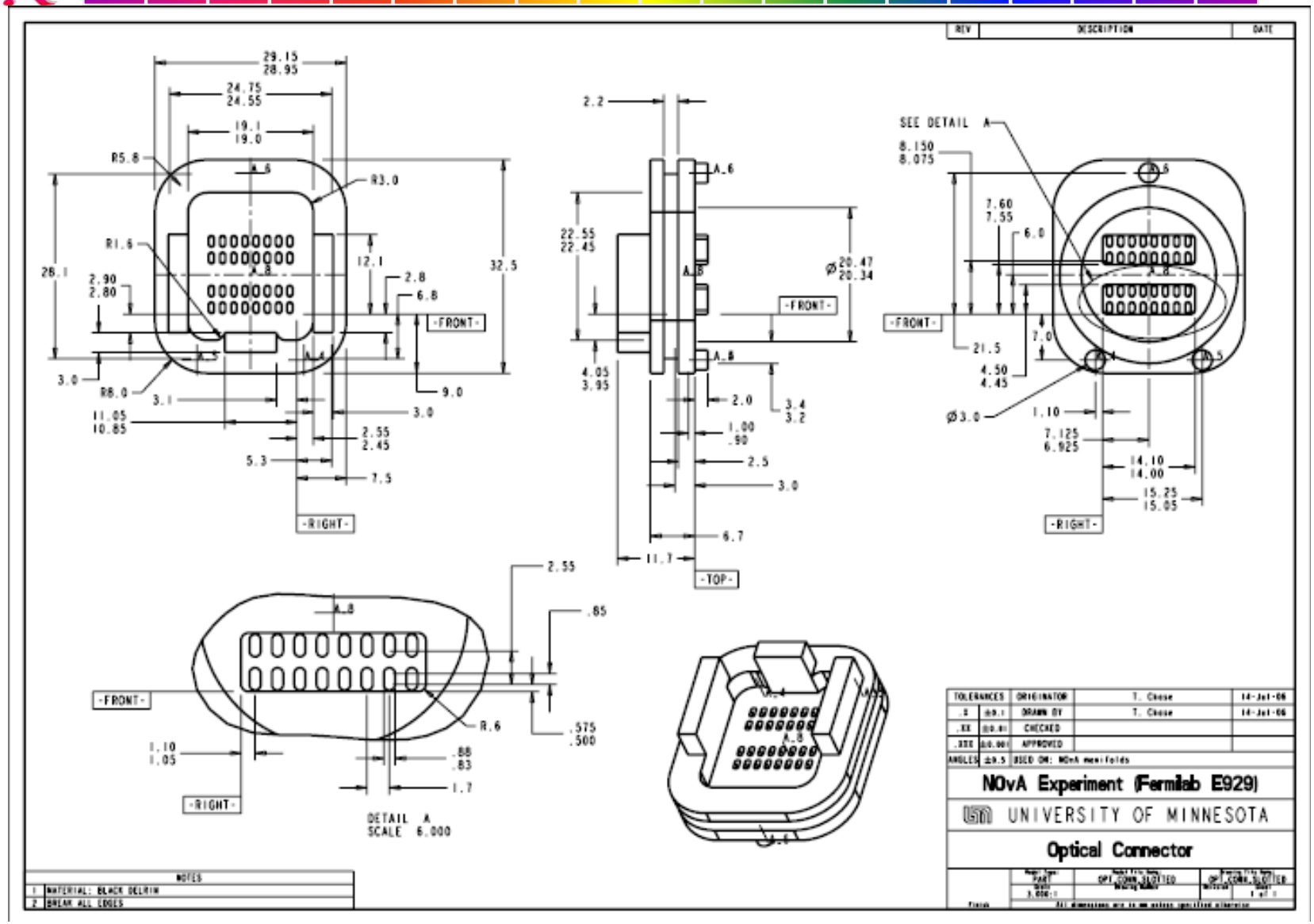
Glue is 3M DP190 Grey

Optical Connector





Optical Connector

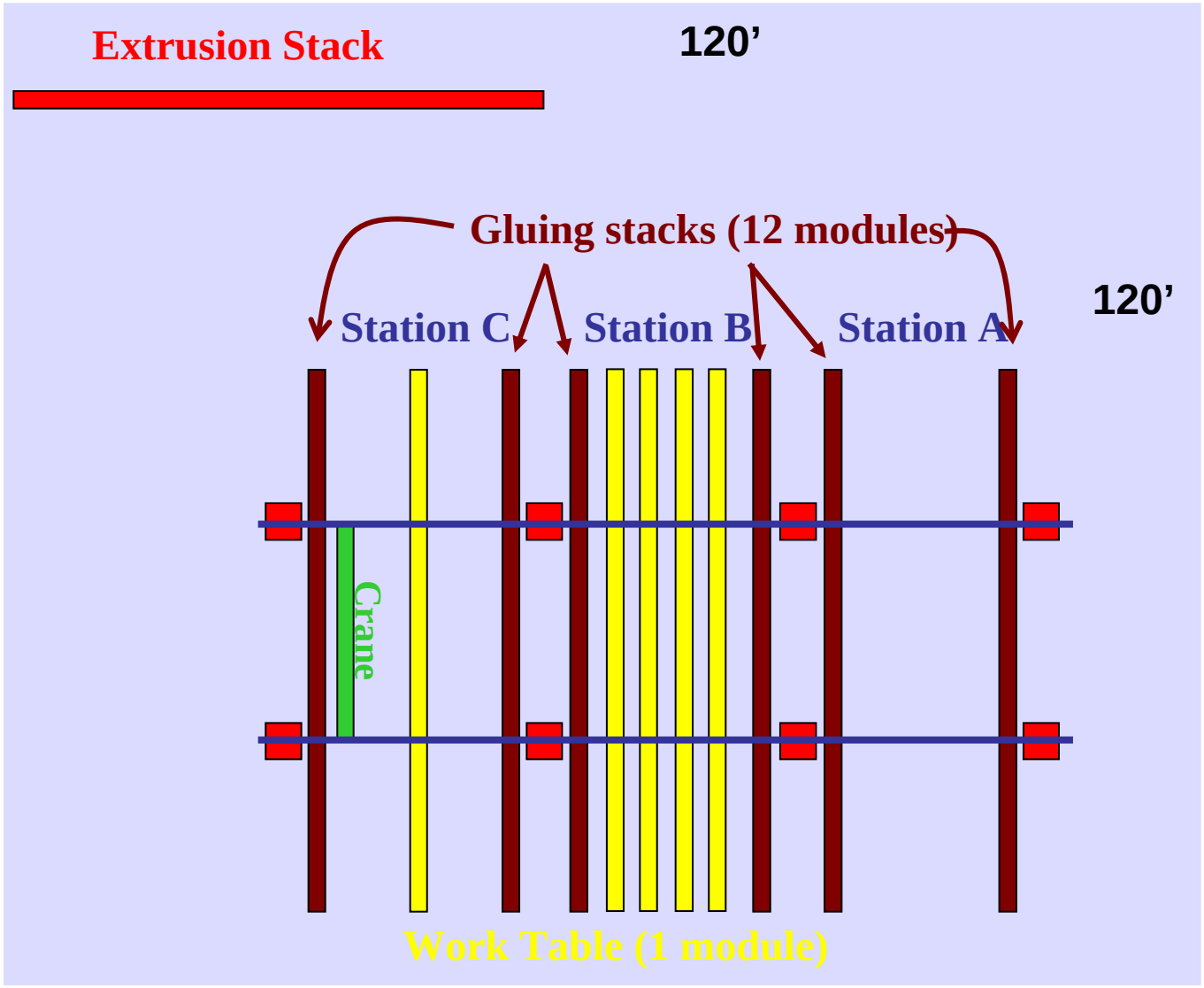


Module Parts

1. **Extrusions - delivered**
2. **Manifolds – parts fabricated**
3. **Overflow tanks – part of detector structure**
4. **Bottom seals - fabricated**
5. **WLS fiber - delivered**
6. **Optical connectors - fabricated**

Glue it all together at the Module Factories

Module Assembly



36 modules/3 days for 1 shift

2.9 person hour/module

Based on time and motion studies (measured & conceptual)

University factory

5 student techs
+ lead technician
+ physicist

Lab factory
All professional technicians

Module Assembly

Module production: 2.9 person hr/module

12 modules/shift (6 hr on task/8 hr shift) with 6 people

60 modules/week for a 5 day week (1 shift/day)

2 factories gives 120 modules/week

Contingency to increase production rate

Option 1: Add a second shift or partial shift

Cost: 1 additional lead technician
additional gluing stacks

Option 2: Add additional work stations

Cost: 1 additional professional technician
additional workstation structure

Delivery schedule interruptions

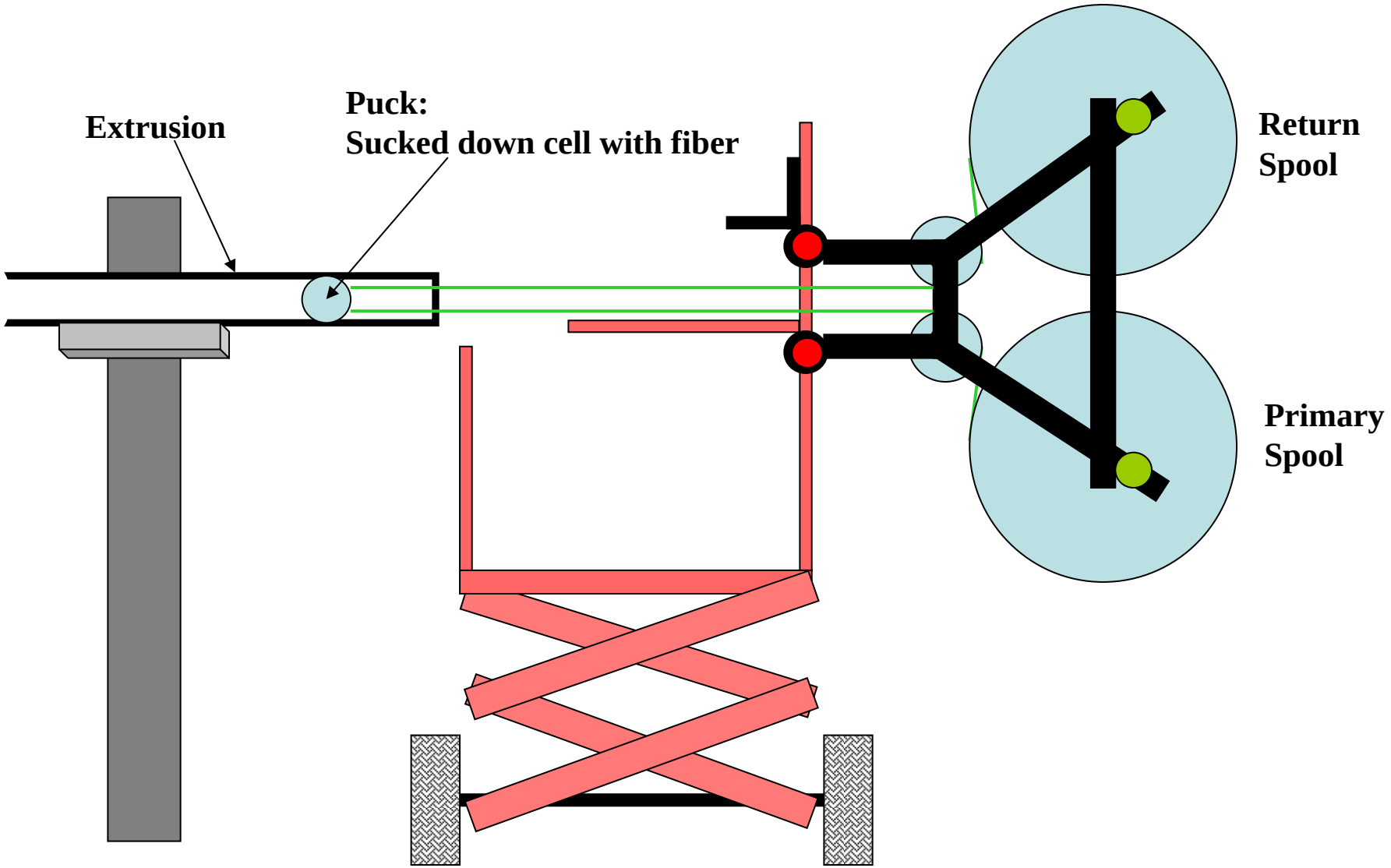
- **Excess factory capacity to increase production rate if necessary**
- **Warehouse space for storing extrusions**
- **Warehouse space for storing modules**

Machines

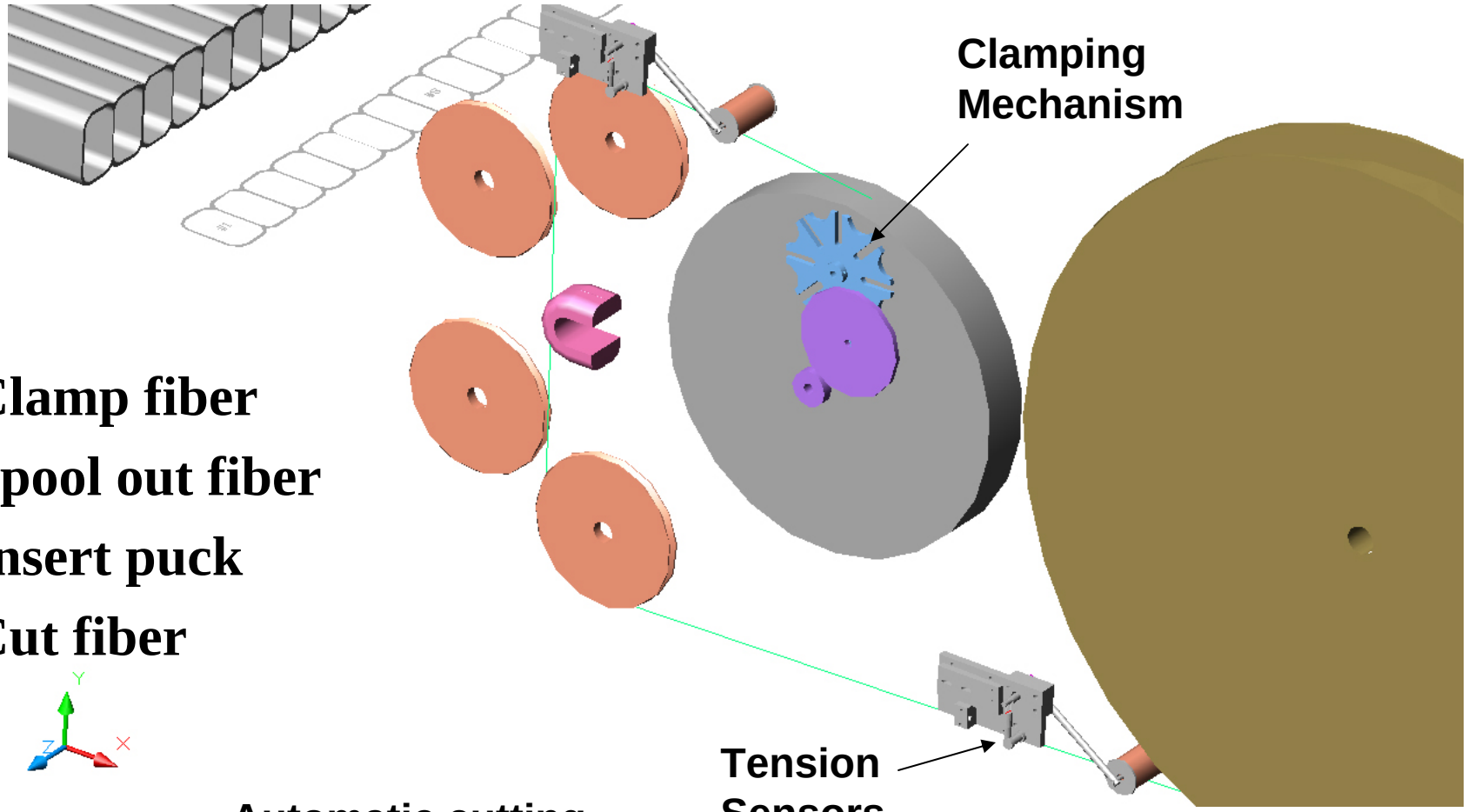
Assembly Machines

- **Fiber Stringing – Build**
- **Gluing – Purchase & modify**
  - **Glue for assembly - Purchase**
- **Fly cutter – Purchase & modify**
- **Crane and lifting - Purchase**
- **Air Lifter and moving - Purchase**

Fiber Stringing Machine



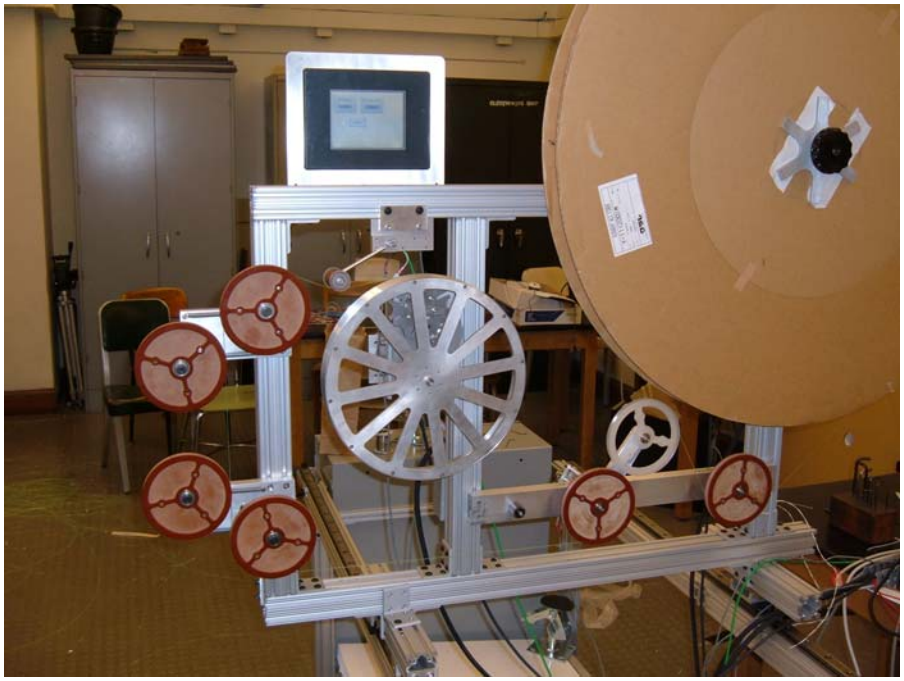
Fiber Stringing Machine

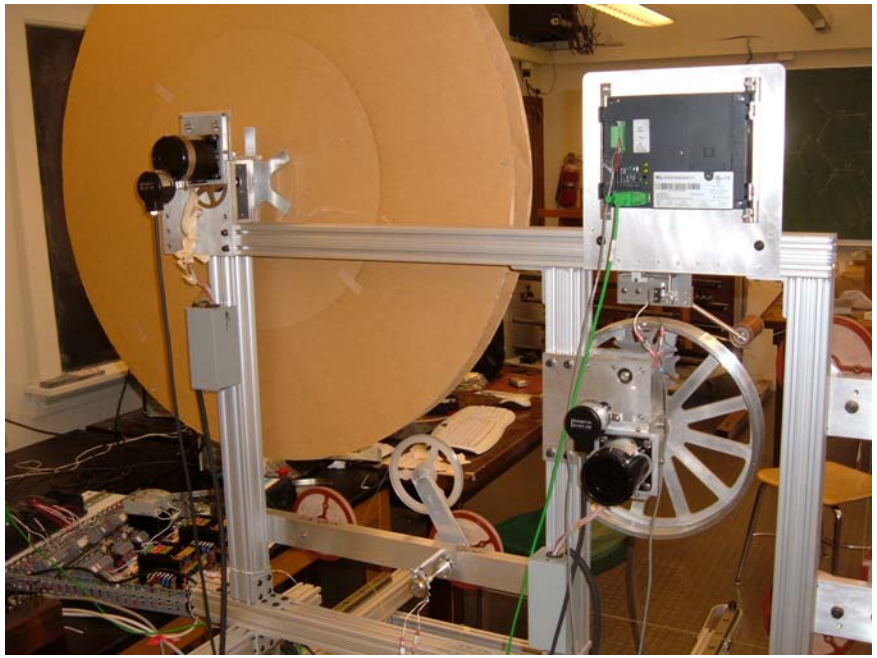


1. Clamp fiber
2. Spool out fiber
3. Insert puck
4. Cut fiber

- Automatic cutting
- Indexing to extrusion-auto fiber length

Fiber Stringing Machine





Health & Safety

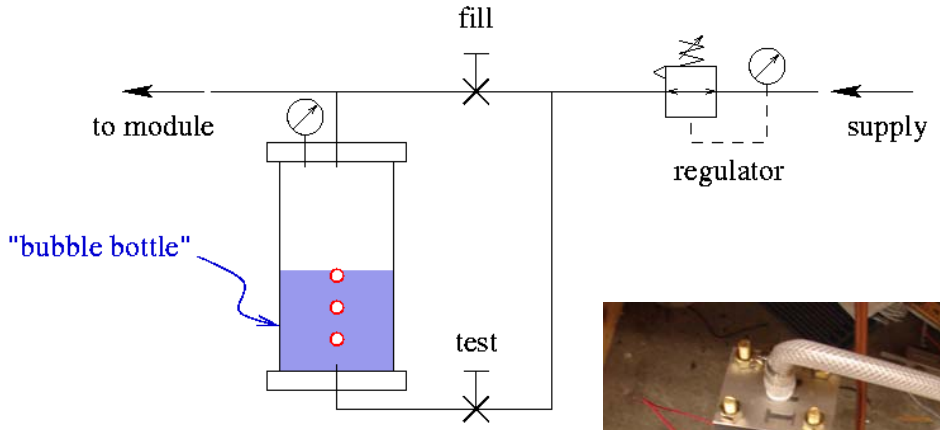
Lifting heavy extrusions (900 lbs each)
- **Lifting fixtures**
- **Training**

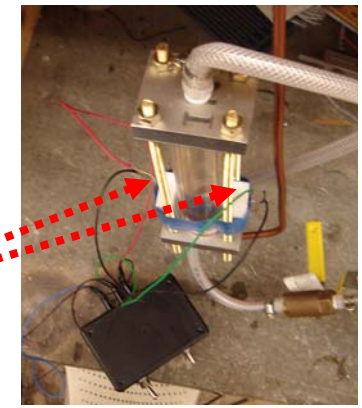
Glue fumes
- **Good ventilation**

Risks & QC

Quality assembly procedure

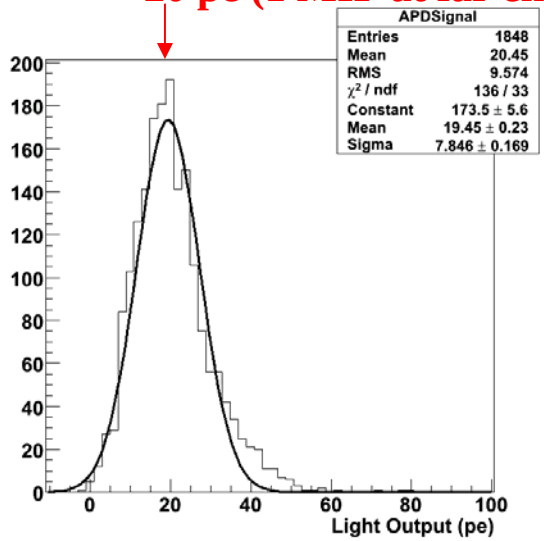
Light flasher to check fiber mapping
Light flasher to check fiber continuity
Sensitive measurements of possible oil leaks for each module
Test light yield of a small sample of modules.





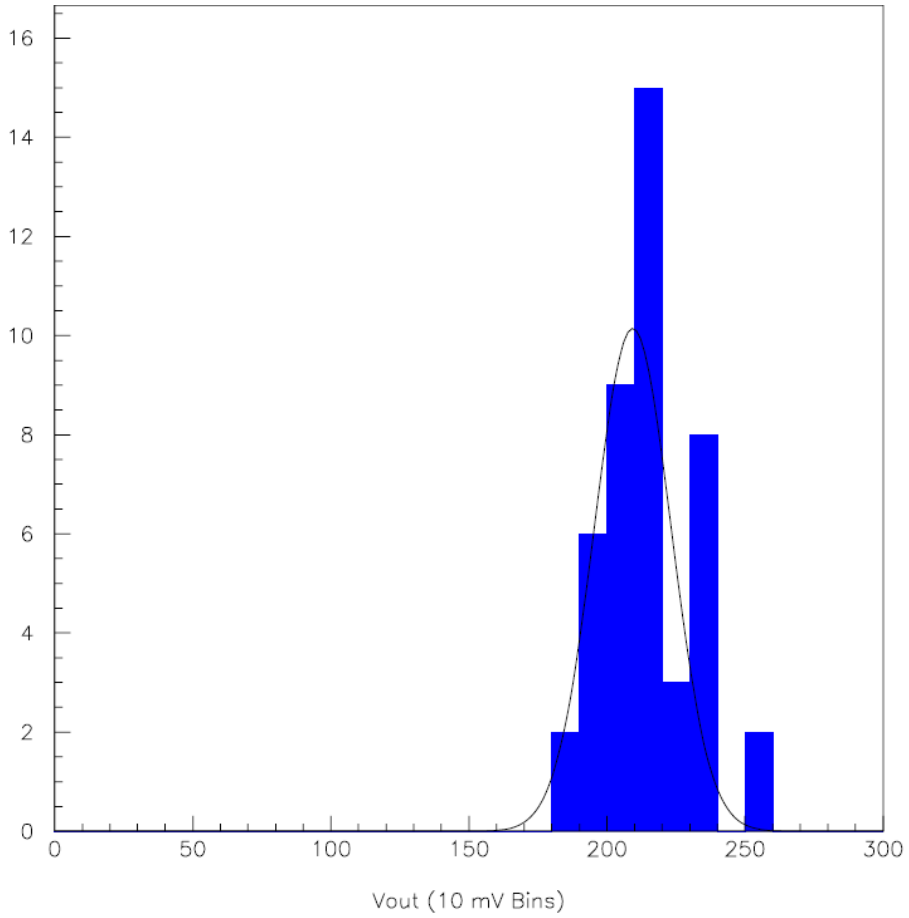
IR sensor/receiver pair

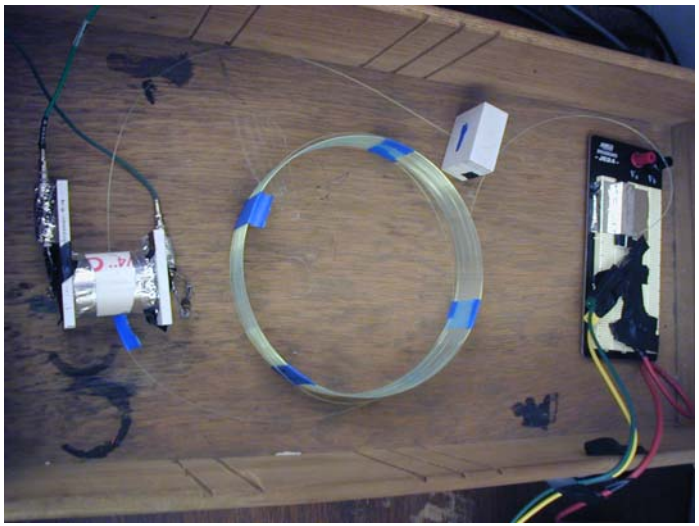
20 pe (1 MIP at far end)



Fiber Damage

DC measurement of fiber quality





6.8 x 10^6 gallons liquid scintillator

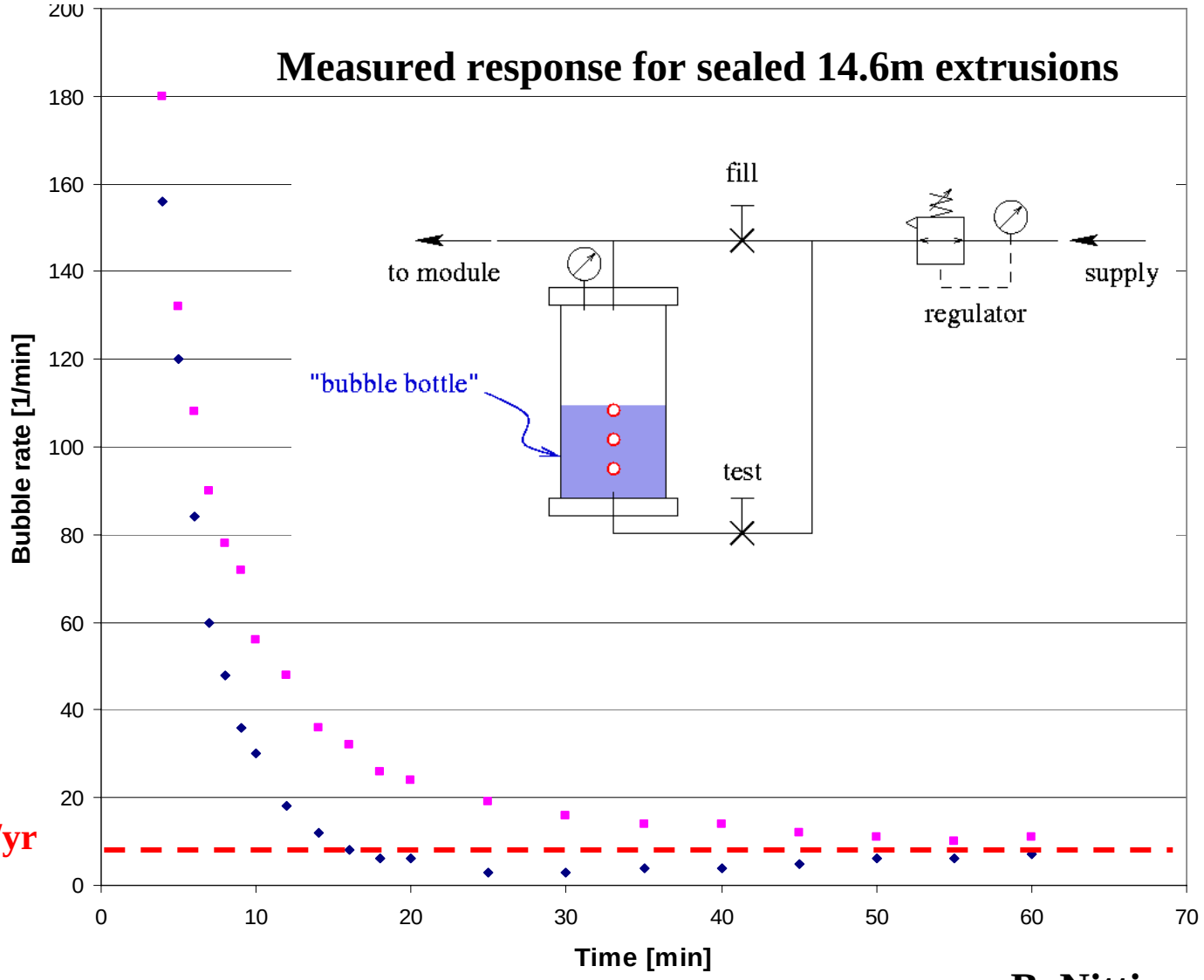
If leak detected
Fix or discard module

How many leaks below leak detection sensitivity?

Example
100% - 680 gallons/yr
1% - 6.8 gallons/yr

Plan
Test 100 end seals for very small leaks

10^{-4} volume of oil/yr for one module (1.5 mm drop)



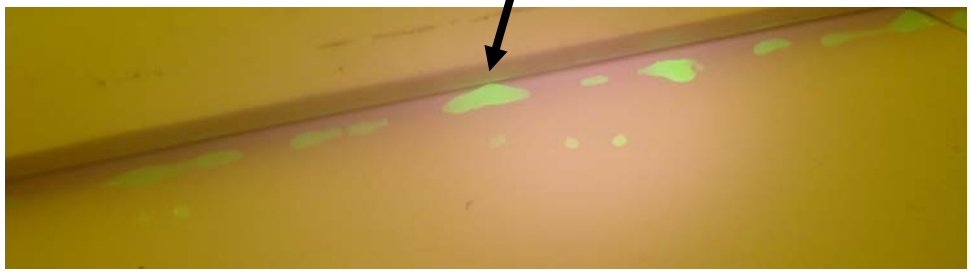
B. Nitti

Small Leaks

Additional Leak Tests

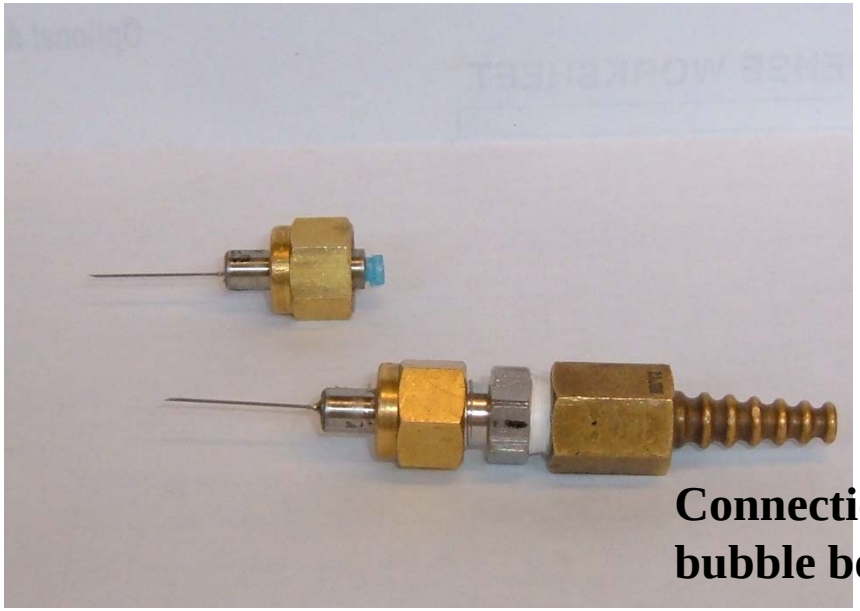
- Bubbles under water
- Bubbles in soap solution
- Fluorescent dye

Dye under black light



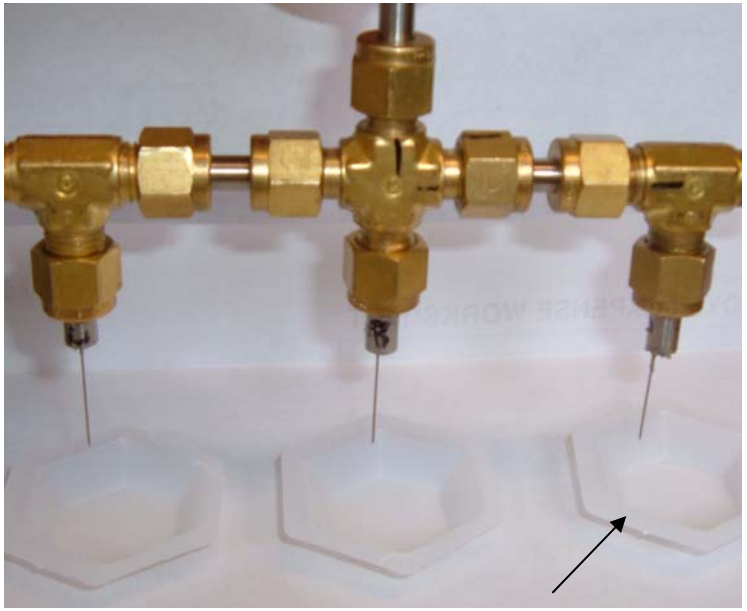
Calibrated Leak

Needle is crimped while observing bubble rate



Connection to bubble bottle

Oil through crimped needle is weighed



Collect oil in dish

Integration Prototype

4 m long, 16 cells wide extrusions – 2 extrusions/module

Ship IPND modules – Begin March 2007 – Finish Aug 2007 (5 months)

- **Assumes Horizontal Extrusions arrive September 2006**
- **Assumes Vertical Extrusions arrive May 2007**

Prototype design of manifolds, end plates, tooling, assembly machines

- **5 Months (includes Christmas and New Year)**
- **Machine first 50 manifolds and end plates**
- **Extrude and injection mold next 450**

Begin module production at rate of 1/day

End module production at rate of 6/day (at 6/day 3 months to complete)

Summary

- **Leak and Gluing studies are progressing**
  - **Of-the-shelf extrusion tests**
    - **Design improvements of manifold and end seal**
  - **Test 16 cell extrusions delivered next week**
    - **Build fixtures**
    - **Expect further design improvements to manifold and end seal**
- **Awaiting extrusion delivery – October??**
  - **Time and motion studies in assembly**
  - **Leak and gluing studies with "real" profile**
  - **Fixture design completion**
  - **Machine design completion**
  - **Finalize design of manifolds and end seals**
- **Factory design and shipping and handling studies are progressing**
- **Cost reviews are continuing**
  - **Typically labor costs go up and contingency goes down**
- **Aiming toward delivery of IPND modules**